teeth. The number of rotor teeth exceeds the number of stator teeth so the rotor teeth overlap the stator teeth. This improves starting torque in a desired direction of motor rotation.

DEPR:
The rotor teeth of motor 50 are spaced so that they overlap a stator pole. This is done to increase the amount of starting torque in the direction of desired motor rotation For motor 50, the spacing between rotor teeth is given by the formula: ##EQU2## where: 360 is the number of degrees in a circle,

DEPR:
While respect to rotor assembly construction, if the stator assembly has only one tooth per pole, then the rotor teeth have a step gap construction to improve starting torque in the desired direction of rotation. If the stator poles have two teeth per pole, then it is important that the rotor have a prescribed number of required teeth based upon the above formula. In order to improve starting torque in a desired direction of motor rotation, the rotor teeth should overlap the stator teeth of other phase poles when one phase is at maximum inductance. The number of rotor teeth is limited by the ability to construct a stator having the appropriate calculated spacing between stator teeth. Thus, as indicated the spacing formula, so long as the result of the spacing calculation exceeds approximates and is

Details | Text | Image | HTML | KWIC

US005239217A

United States Patent [19]
Horst

[11] **Patent Number: 5,239,217**
[45] **Date of Patent: Aug. 24, 1993**

[54] **REDUNDANT SWITCHED RELUCTANCE MOTOR**

[75] Inventor: Guy R. Horst, County of St. Louis, Mo.

[73] Assignee: Emerson Electric Co., St. Louis, Mo.

[21] Appl. No.: 884,149

[22] Filed: May 15, 1992

[51] Int. Cl.[5] H02K 5/24; H02K 1/24
[52] U.S. Cl. 310/51; 310/269; 310/158
[58] Field of Search 310/51, 168, 254, 261, 310/269

[56] **References Cited**
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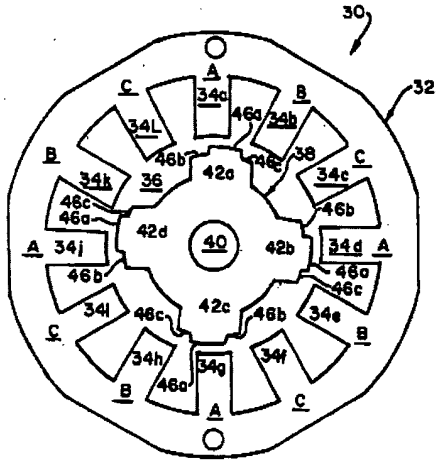
Primary Examiner—Emanuel T. Voeltz
Assistant Examiner—Judson H. Jones
Attorney, Agent, or Firm—Polster, Lieder, Woodruff & Lucchesi

[57] **ABSTRACT**

A multiple phase switched reluctance motor (30). A stator assembly (32) has a plurality of inwardly salient teeth (34a–34l) terminating at a central bore (36). A rotor assembly (38) is disposed for rotation in the bore and has a plurality of rotor teeth (42a–42d). The stator assembly has at least one redundant pole set for each motor phase. The rotor assembly has a corresponding proportional number of rotor teeth. The redundancy of the poles helps distribute ovalizing forces on the motor assembly. This lessens the effect of these forces and reduces motor noise produced by the assembly in response to the forces. In addition, the stator can have multiple teeth per pole and the rotor a multiple of the determined rotor teeth. The number of rotor teeth exceeds the number of stator teeth so the rotor teeth overlap the stator teeth. This improves starting torque in a desired direction of motor rotation.

14 Claims, 8 Drawing Sheets



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DOCUMENT-IDENTIFIER: US 4348605 A
TITLE: Electrical reluctance machine

---------- KWIC ---------

DEPR:
During clockwise rotation (as viewed in FIG. 4) and with the rotor position
shown in FIG. 4, two of the rotor poles, namely those which are nearest the
stator poles B4 and B7, are in a drawing-in position, whereas the two rotor
poles which overlap the stator poles B5 and B2 are in the process of moving
away from these stator poles. Since the magnetic flux is approximately equally
great at all four overlapping points, it is easy to believe that the resultant
torque would be almost equal to zero. This, however, is not the case, since
the m.m.f. in the overlapping zones between a stator pole and a rotor pole to
a great extent determines the torque that the stator pole exerts on the rotor
pole.

CCOR:
310/168

United States Patent [19]
Türük

[11] 4,348,605
[45] Sep. 7, 1982

[54] ELECTRICAL RELUCTANCE MACHINE
[75] Inventor: Vilnos Türük, Lidingö, Sweden
[73] Assignee: ASEA Aktiebolag, Vasterås, Sweden
[21] Appl. No.: 131,890
[22] Filed: Mar. 19, 1980
[30] Foreign Application Priority Data
Mar. 30, 1979 [SE] Sweden 7902845
[51] Int. Cl.³ H02K 19/06
[52] U.S. Cl. 310/168; 310/152; 310/181; 318/701
[58] Field of Search 310/181, 162, 163, 168, 310/154, 155; 318/701

[56] References Cited
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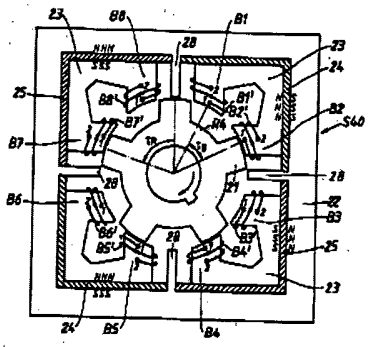
Primary Examiner—Donovan F. Duggan
Attorney, Agent, or Firm—Pollock, Vande Sande & Priddy

[57] ABSTRACT

A reluctance machine comprises a rotor having a plurality of unwound salient rotor poles, and a stator with an even number of mutually equal groups of salient stator poles evenly distributed around the inner circumference of the stator unit, each stator pole being surrounded by a respective working coil. The stator poles belonging to the same group have the same polarity and also the same premagnetization. The polarity is determined by the working coils being distributed between at least two working windings which are each provided with a rectifying means. Between two stator poles, whose working coils belong to one and the same working winding, there is at least one stator pole which supports a working coil belonging to some other working winding.

14 Claims, 23 Drawing Figures



DOCUMENT-IDENTIFIER: US 6359360 B1
TITLE: Electronically switched two phases reluctance machine

---------- KWIC ---------

DEPR:
There is a correct function of the machine when the overlapping of the rotor
(121) or stator poles 111 is selected such that, when the stator-rotor poles of
the phase X correspond to each other (position tooth-tooth), the stator-rotor
poles of the second phase are displaced around the angle w (position
tooth-gap). The position of the phase magnets with respect to the angle w
(=pole width,=gap width) is the following:

DEPR:
The poles 111X (the yokes 11X) are fixed in such a way, so that this happens,
that they begin to attract straight rotor teeth 121, when these teeth (121)
have passed over the maximal overlapping with the poles 111Y.

CCOR:
310/168

US006359360B1

(12) **United States Patent**
Lungu

(10) Patent No.: **US 6,359,360 B1**
(45) Date of Patent: **Mar. 19, 2002**

(54) **ELECTRONICALLY SWITCHED TWO PHASES RELUCTANCE MACHINE**

(76) Inventor: Iancu Lungu, Str. Trepanilei nr. 5 G1A ap=40, sector 3, RO-74381 Bukarest (RO)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/308,518
(22) PCT Filed: Nov. 19, 1997
(86) PCT No.: PCT/RO97/00007
§ 371 Date: Dec. 24, 1999
§ 102(e) Date: Dec. 24, 1999
(87) PCT Pub. No.: WO98/23024
PCT Pub. Date: May 28, 1998
(30) Foreign Application Priority Data
Nov. 20, 1996 (RO) 96-02186
(51) Int. Cl.[7] H02K 17/00; H02K 17/42
(52) U.S. Cl. 310/168; 310/171
(58) Field of Search ..... 310/166, 168, 310/49 R, 254, 171, 112

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One page description entitled Retarder; dated Feb. 15, 1969; inventor: Takayuki Suzuki; application No. 64-35500.

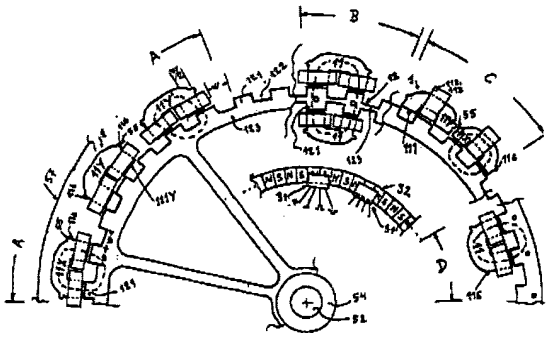
* cited by examiner

Primary Examiner—Nestor Ramirez
Assistant Examiner—Dang Dinh Le
(74) *Attorney, Agent, or Firm*—Kelly Bauersfeld Lowry & Kelley, LLP

(57) **ABSTRACT**

This switched reluctance machine has at least six magnet yokes (11) on the stator side. The yokes are placed circularly and they carry windings (112). These yokes (11) can be placed at the inner side and/or the outer side of the rotor (12). These yokes which are magnetically insulated to each other interact with the salient poles (121) of the rotor (12). The two phases (X, Y) of this machine are push-pull controlled by a Hall sensor (31). This way the electronic circuitry becomes very simple.

12 Claims, 2 Drawing Sheets



has at least one redundant pole set for each motor phase. The rotor assembly has a corresponding proportional number of rotor teeth. The redundancy of the poles helps distribute ovalizing forces on the motor assembly. This lessens the effect of these forces and reduces motor noise produced by the assembly in response to the forces. In addition, the stator can have multiple teeth per pole and the rotor a multiple of the determined rotor teeth. The number of rotor teeth exceeds the number of stator teeth so the rotor teeth overlap the stator teeth. This improves starting torque in a desired direction of motor rotation.

DEPR:
The rotor teeth of motor 50 are spaced so that they overlap a stator pole. This is done to increase the amount of starting torque in the direction of desired motor rotation For motor 50, the spacing between rotor teeth is given by the formula: ##EQU2## where: 360 is the number of degrees in a circle,

DEPR:
While respect to rotor assembly construction, if the stator assembly has only one tooth per pole, then the rotor teeth have a step gap construction to improve starting torque in the desired direction of rotation. If the stator poles have two teeth per pole, then it is important that the rotor have a prescribed number of required teeth based upon the

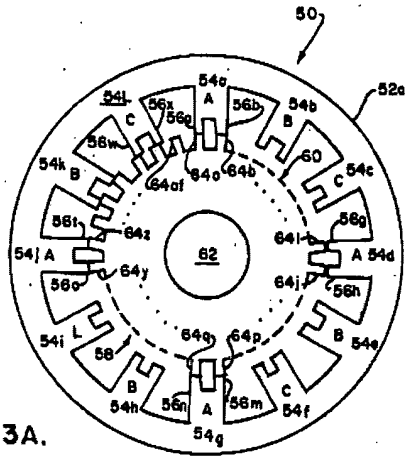


FIG. 3A.

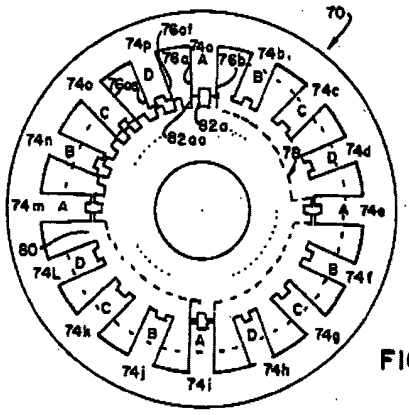


FIG.4.

schemes utilizing
overlapping bi-polar excitation currents are envisioned. One such bi-polar
excitation scheme is illustrated in FIGS. 13A-13C.

DEPR:
Because overlapping currents are utilized in the energization scheme of FIGS.
13A-13C it is possible to produce more torque as a function of the chances in
the mutual-inductances between the various phase windings. Thus, the total
torque output for the machine 90 of FIG. 9, T, when energized with overlapping
currents, may be generally expressed as: ##EQU31##

DEPR:
FIG. 13B illustrates an exemplary energization scheme utilizing overlapping
bi-polar currents to produce positive output torque in a desired direction.
According to the illustrated energization scheme: (i) the phase A winding is
energized with positive current during the intervals of rotor rotation over
which the self-inductance of the phase A winding is increasing (e.g., the
0.degree.-30.degree., 90.degree.-120.degree. and 180.degree.-210.degree.
intervals); (ii) the phase B winding is energized with negative current during
the intervals of rotor rotation over which the self-inductance of the phase B
winding is increasing (e.g., the 0.degree.-30.degree., 90.degree.-120.degree.
and 180.degree.-210.degree. intervals); (iii) the phase C winding is energized
with positive current during the intervals of rotor rotation over which the

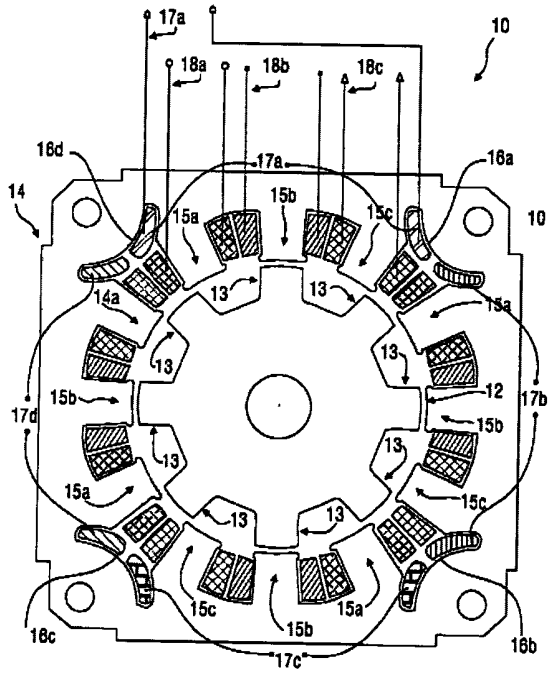


FIG. 1

overlap with the energized stator poles associated with the phase A winding (e.g., a 9.degree. overlap). As illustrated in the figure, the flux flow through the energized phase windings is extensive and, depending on the magnitude of the current flowing in the phase A winding, will often be limited by the saturation characteristics of the material used to construct the stator. Further, as reflected in FIG. 20A, all of the flux flow in the traditional machine is directed through the energized stator poles, thus contributing to localized saturation of the stator.

CLPR:
16. The doubly-fed reluctance machine system of claim 15 wherein the single excitation converter provides non-overlapping, uni-polar currents to the electrical connections between the phase windings from the first and second sets.

CLPR:
17. The doubly-fed reluctance machine system of claim 15 wherein the single excitation converter provides overlapping bi-polar currents to the electrical connections between the phase windings from the first and second sets.

CCXR:
310/166

US005811905A

United States Patent [19]
Tang

[11] Patent Number: 5,811,905
[45] Date of Patent: Sep. 22, 1998

[54] **DOUBLY-FED SWITCHED RELUCTANCE MACHINE**

[75] Inventor: Yihan Tang, St. Louis, Mo.

[73] Assignee: Emerson Electric Co., St. Louis, Mo.

[21] Appl. No.: 778,570

[22] Filed: Jan. 7, 1997

[51] Int. Cl.[6] H02K 19/00; H02K 19/10; H02K 19/12

[52] U.S. Cl. 310/179; 310/162; 310/166; 310/184; 310/185; 318/254; 318/701

[58] Field of Search 310/179, 185, 310/155, 197, 184, 162, 166, 168; 318/254, 701

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Primary Examiner—Steven L. Stephan
Assistant Examiner—B. Mullins
Attorney, Agent, or Firm—Arnold, White & Durkee

[57] **ABSTRACT**

A doubly-fed switched reluctance machine in which at least two sets of phase winding are energized to produce desired output torque is disclosed. Also disclosed are dual and single power converters for energizing the doubly-fed machine as well as exemplary excitation schemes position. Sensorless techniques and systems for controlling the doubly-fed machine, and other machines having fully-pitched or fractional-pitched windings, are also disclosed.

22 Claims, 35 Drawing Sheets